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## THE BRITISH ASSOCIATION MEETING.

THE address of Professor A. C. Ramsay, the President of the British Association, although a masterpiece of its kind, was hardly one to excite general attention, the scope of the subject (geology) being necessarily narrow. The address of Professor W. G. Adams, the President of the Mathematical and Physical Section, was of a different nature, and is one likely to prove of considerable interest to scientific men generally. Departing from our usual course, therefore, we do not propose to give Professor Ramsay's address, but to give that of Professor Adams' at length, as follows :—

It has been said by a former President of this Section of the British Association, that the President of a Section ought to occupy your time, not by speaking of himself or his own feelings, but by a review, "more or less extensive of those branches of science which form the proper business of this section." He may give a rapid sketch of the progress of mathematical science during the year, or he may select some one special subject, or he may take a middle course, neither so extensive as the first nor so limited as the second.

There are many branches of science which have always been regarded as properly belonging to our Section, and the range is already wide; but it is becoming more and more true every day that the sciences which are dealt with in other sections of the Association are becoming branches of physics, *i.e.*, are yielding results of vast importance when the methods and established principles of physics are applied to them. I wish to direct your attention to investigations which are being made in that fertile region for discovery, the "border land" between chemistry and physics, where we have to deal with the constitution of bodies, and where we are tempted to speculate on the existence of matter and on the nature of the forces by which the different parts of it are bound together, or become so transformed that all resemblance to their former state is lost. It is not long since the theory of exchanges became thoroughly recognised in the domain of radiant heat, and yet it is already recognised and accepted in the theory of chemical combination. Just as the molecules of a body which remains at a constant temperature are continuously giving up their heat motion to surrounding molecules, and getting back from them as much motion of the same kind in return, so in a chemical compound which does not appear to be undergoing change, the combining molecules are continuously giving up their chemical or combining motions, to surrounding molecules and receiving again from them as much combining motion in return. We may say that each molecule is, as far as we can see, constantly dancing in perfect time with a partner, and yet is continuously changing partners. When such an idea of chemical motion is accepted, we can the more easily understand that chemical combination means the alteration of chemical motion which arises from the introduction of a new element into the space already occupied, and the consequent change in the motion of the new compound as revealed to us in the spectroscope. We can also the more readily understand that in changing from the old to the new form or rate of motion, there may be a development of energy in the shape of heat motion which may escape or become dissipated wherever a means of escape presents itself. We know from the experiments of Joule and of M. Favre that as much heat is absorbed during the decomposition of an electrolyte as is given out again by the combination of the substances composing it.

We are making rapid strides towards the exact determination of those relations between the various modes of motion or forms of energy which were so ably shadowed forth, and their existence established long ago, by Sir William Grove in his Correlation of the Physical Forces, where, in stating the conclusion of his comparison of the mutual interchange of physical forces, he distinctly lays down the principles of energy in this statement, "Each force is definitely and equivalently convertible into any other; and where experiment does not give the full equivalent, it is because the initial force has been dissipated, not lost, by conversion into other unrecognised forces. The equivalent is the limit never practically reached."

The laws of Faraday, that (1) when a compound is electrolysed the mass of the substance decomposed is proportional to the quantity of electricity which has produced the change, and that (2) the same current decomposes equivalent quantities of different substances —*i.e.*, quantities of their elements in the ratio of their combining numbers, have given rise to several determinations of the relation between chemical affinity and electromotive force. In a paper lately communicated to the Physical Society, Dr. Wright has discussed these several determinations, and has given an account of a new determination by himself. The data at present extant show that when 1 gramme of hydrogen unites with 7·98 grammes of oxygen there are about 34,100 units of heat given out, making the latent heat of dissociation of *1 gramme of water equal to 3,797 units*. The results obtained are compared with the heat given out by the combustion of hydrogen and oxygen, and the value of the mechanical equivalent of heat is deduced from these determinations.

The value of this mechanical equivalent obtained by Dr. Wright, which depends on the value of Clark's standard cell, and, therefore, depends upon the value of the ohm, agrees fairly well with Joule's determination from the heat produced by an electric current in a wire, but is greater than Joule's value as obtained from his water-friction experiments. This may be accounted for by supposing an error in the value of the ohm or B.A. unit, making it too large by 1·5 or 2 per cent. Kohlrausch has also made comparisons of copies of the B.A. unit with standard coils, and comes to the conclusion that the B.A. unit is 1·96 per cent. too large. On the other hand, Professor Rowland, in America, has made a new determination, and finds that according to his calculations the B.A. unit is nearly 1 per cent. too small. These differences in the values obtained by different methods clearly point to the necessity for one or more new determinations of the unit, and I would venture to suggest that a determination should be made under the authority of this Association, by a committee appointed to carry out the work. And it is not sufficient that this determination should be made once for all, for there is reason to think that the resistance of standard coils alters with time, even when the material has been carefully selected. It has been found that coils of platinum silver which were correct copies of the standard ohm

have become so altered, and have their temperature coefficients so changed, that there are doubts as to the constancy of the standards themselves. Pieces of platinum-silver alloy cut from the same rod have been found to have different temperature coefficients. The value ·031 for 1°C. is given by Matthiessen for this alloy, yet two pieces of wire drawn from the same rod have given, one ·021 per cent. and the other ·04 per cent. for 1°C.

Possibly this irregularity in the platinum-silver alloys may be due to something analogous to the segregation which Mr. Roberts has found to take place in copper-silver alloys in their molten state, and which Matthiessen in 1860 regarded as mechanical mixtures of allotropic modifications of the alloy.

A recommendation has been made that apparatus for determining the ohm should be set up in London, and that periodically determinations be made to test the electrical constancy of the metals and alloys used in making coils. A committee should be authorised to test coils and issue certificates of their accuracy, just as is done by the Kew Committee with regard to meteorological instruments. The direct relation between heat and chemical work has been established, and the principles of conservation of energy been shown to be true in chemistry by the experiments of Berthelot and of Thomsen, so that we may say that when a system of bodies passes through any succession of chemical changes, the heat evolved or absorbed when no external mechanical effect is produced depends solely upon the initial and final states of the system of bodies, whatever be the nature or the order of the transformations. The extension of this principle to the interaction of the molecules and atoms of bodies on one another is of vast importance in relation to our knowledge of the constitution of matter, for it enables us to state that each chemical compound has a distinct level or potential which may be called its own, and that when a compound gives up one of its elements to another body, the heat evolved in the reaction is the difference between the heat of formation of the first compound and that of the resulting product.

We have become accustomed to regard matter as made up of molecules, and those molecules to be made up of atoms separated from one another by distances which are great in comparison with the size of the atom, which we may regard as the smallest piece of matter that we can have any conception of. Each atom is surrounded by an envelope of ether which accompanies it in all its movements. The density of the ether increases rapidly as an atom is approached, and it would seem that there must be some force of attraction between the atom and its ether envelope. All the atoms have motions of translations in all possible directions, and according to the theories of Maxwell and Boltymann, and the experiments of Kundt, Warburg, and others on the specific heat of vapours, in one-atom molecules in the gaseous state there is no motion of rottaion. According to the theory of Pictet, the liquid state being the first condensation from the gaseous state must consist of at least two gaseous atoms combined. These two atoms are bound to one another through their ether envelopes. Then the solid state results from the condensation of a liquid, and so a solid molecule must consist of at least two liquid molecules, *i.e.*, at least four gaseous molecules, each surrounded by an atmosphere of ether. M. Pictet imagines these atoms to be centres of attraction; hence in the solid with four such centres the least displacement brings into action couples tending to prevent the molecule from hoisting as soon as external forces act upon it. All the molecules constituting a solid will be rigidly set with regard to one another, for the least displacement sets in action a couple or an opposing force in the molecules on one another.

Let us now follow the sketch which M. Pictet has given of changes which we may consider it to undergo when we expend energy upon it. Suppose a solid body is at absolute zero of temperature, which may be regarded as the state in which the molecules of a body are in stable equilibrium and at rest, the application of heat gives a vibratory motion to the molecules of the solid, which increases with the temperature, the mean amplitude of vibration being a measure of the temperature. We may regard the sum of all the molecular forces as the specific heat of the body, and the product of the sum of all the molecular forces by the mean amplitude of the oscillations; *i.e.*, the product of the specific heat and the temperature will be the quantity of heat or the energy of motion of the body. As more and more heat is applied, the amplitude of vibration of the molecules increases until it is too great for the molecular forces, or forces of cohesion, and the melting-point of the solid is reached. Besides their vibratory motion, the molecules are now capable of motions of translation from place to place among one another. To reduce the solid to the liquid state, *i.e.*, to make the amplitude of vibration of the molecules sufficient to prevent them from coming within the sphere of the forces of cohesion, requires a quantity of heat which does not appear as temperature or molecular motion, and hence it is termed the latent heat of fusion. The temperature remains constant until the melting is complete, the heat being spent in bursting the bonds of the solid. Then a further application of heat increases the amplitude of vibration, or raises the temperature of the liquid at a rate depending on its specific heat until the succession of blows of the molecules overcomes the external pressure and the boiling-point is reached. An additional quantity of heat is applied which is spent in changing the body to a gas, *i.e.*, to a state of higher potential, in which the motion of translation of the molecules is enormously increased. When this state is attained, the temperature of the gas again begins to increase, as heat is applied, until we arrive at a certain point, when dissociation begins, and the molecules of the separate substances of which the body is composed have so large an amplitude of vibration that the bond which unites them can no longer bring them again into their former positions. The potential of the substances is again raised by a quantity which is proportional to its chemical affinity. Again, we may increase the amplitude of vibration, *i.e.*, the temperature of the molecules, and imagine the possibility of getting higher and higher degrees of dissociation.

If temperature means the amplitude of vibration of the molecules, then only those bodies which have their temperatures increased by the same amount when equal amounts of heat are applied to them can possibly combine with one another; and so the fact that the increase of temperature bears a fixed ratio to the increase of heat may be the cause in virtue of which bodies can combine with one another. Were other bodies to begin to combine together at any definite temperature, they would immediately be torn to pieces again when the temperature is even slightly raised, because the amplitudes of vibration of their molecules no longer remain the same. This idea of temperature is supported by the fact that a combining molecule of each substance requires the same amount of heat to raise its temperature by the same number of degrees, the atomic weights being proportional to the masses of the combining molecules. The celebrated discovery of Faraday, that in a voltameter the work done by an electric current always decomposes equivalent quantities of different substances, combined with the fact that

in the whole range of the physical forces work done is equivalent to the application heat, is quite in accordance with the view that no molecule can combine with another which has not its amplitude of vibration altered by the same amount when equal quantities of heat are applied to both. As soon as we get any divergence from this state of equal motions for equal increments of heat, then we should expect that a further dissociation of molecules would take place, and that only those which are capable of moving together can remain still associated. Just as in the change of state of a body from the solid to the liquid, or from the liquid to the gas, a great amount of heat is spent in increasing the motion of translation of the molecules without altering the temperature, so a great amount of heat is spent in producing dissociation without increasing the temperature of the dissociated substances, since the principle of conservation of energy has been shown by M. Berthelot to hold for the dissociation of bodies. We may conveniently make use of the term latent heat of dissociation, for the heat required to dissociate a unit of mass of a substance.

We may thus sum up the laws of physical and chemical changes:—

1. All the physical phenomena of change of state consist in the subdivision of the body into molecules or particles identical with one another.

2. The reconstitution of a body into a liquid or a solid being independent of the relative position of the molecules, only depends on the pressure and temperature.

3. Dissociation separates bodies into their elements, which are of different kinds, and the temperature remains constant during dissociation.

4. The reunion of dissociated bodies depends on the relative position of the elements, and so depends on the grouping of the molecules. The atomic weight being the mass of a molecule as compared with hydrogen, the specific volume, *i.e.*, the atomic weight divided by the density, is the volume or *mean free path* of a molecule.

Building up his theory of heat on these principles, M. Pictet arrives at a definite relation between the atomic weight of a body, its density, its melting-point, and its coefficient of expansion, which may be stated thus—

The volume of a solid body will be increased as the temperature rises by an amount which is proportional to the number of molecules in it, and inversely as its specific heat. At a certain temperature peculiar to each body, the amplitude of the heat oscillation is sufficient to melt the solid, and we are led to admit that for all bodies the intermolecular distance corresponding to fusion ought to be the same. The higher the point of fusion of a body, the shorter, on this theory, must be its heat vibrations. The product of the length of *swing* (the heat oscillations) by the temperature of fusion ought to be a constant number for all solid bodies.

A comparison of the values of the various quantities involved in these statements shows a very satisfactory agreement between theory and experiment, from which it appears that for many different substances the product of the length of swing by the temperature of fusion lies between 3·3 and 3·7 for most substances. Not many values of the latent heat of dissociation have been made. In order to determine it, say, for the separation of oxygen and hydrogen, we should have to determine the amount of work required to produce a spark in a mixture of oxygen and hydrogen, and to measure the exact amount of water or vapour of water combined by the spark as well as the range of temperature through which it had passed after its formation.

Our usual mode of producing heat is by the combination of the molecules of different substances, and we are limited in the production of high temperatures, and in the quantity of available heat necessary to dissociate any considerable quantity of matter. If we heat vapours or gases, we may raise their temperatures up to a point corresponding to the dissociation of their molecules, and we are limited in our chemical actions to the temperatures which can be obtained by combining together the most refractory substances, as we are dependent on this combination for our supply of heat.

The combination of carbon and hydrogen with oxygen will give us high temperatures, so that by the oxyhydrogen blow-pipe most of the salts and oxides are dissociated.

The metalloids bromine, iodine, sulphur, potassium, &c., are the results of the combination of two or more bodies bound together by internal forces much stronger than the affinity of hydrogen or carbon for oxygen, for approximately they obey the law of Dulong and Petit.

For higher temperatures, in order to dissociate the most refractory substances, we require the electric current, either a continuous current, as in the electric arc from a battery or a dynamo machine, or, more intense still, the electrical discharges from an electrical machine or from an induction coil.

This electric current may be regarded as the most intense furnace for dissociating large quantities of the most refractory substances, and the electric spark may be regarded as something very much hotter than the oxyhydrogen blow-pipe, and therefore of service in reducing very small quantities of substances which will yield to no other treatment. The temperature of the electric arc is limited, and cannot reach above the temperature of dissociation of the conductor, and in the case of the constant current, which will not leap across the smallest space of air unless the carbons have first been brought in contact, the current very soon ceases when the point of fusion has been reached. Yet in the centre of the arc we have the gases of those substances which form the conductor; and, as Professor Dewar has shown, we have the formation of acetyline and cyanogen and other compounds, and therefore must have attained the temperature necessary for their formation, *i.e.*, the temperature of their dissociation. The temperature of the induction spark, or, at least, its dissociating power, is higher than that of the arc. We know that the spark will pass across a space of air or a gaseous conductor, and we are limited by the dissociation of the gaseous conductor, and get only very small quantities of the dissociated substances, which immediately recombine, unless they are separated. If the gases formed are of different densities they will diffuse at different rates through a porous diaphragm, and so may be obtained separated from one another. As the molecules of bodies vibrate they produce vibrations of the ether particles, the period of the oscillations depends on the molecules of the body, and these periodic vibrations are taken up by their ether envelopes and by the luminiferous ether, and their wave-length determined by means of the spectroscope. The bright line spectrum may be regarded as arising from the vibratory motions of the atoms. As the temperature is increased, the amplitudes of oscillation of the molecules and of the ether increase, and from the calculations of Lecoq de Boisbandran, Stoney, Soret, and others, it would appear that many of the lines in the spectra of bodies may be regarded as harmonics of a fundamental vibration. Thus Lecoq de Boisbandran finds that in the nitrogen spectrum the blue lines seen at a high temperature correspond to the double octave of certain vibrations, and that, at a lower temperature, red and yellow lines are seen which correspond to a fifth of the same fundamental vibrations.

The bright line spectrum may be regarded as arising from the vibratory motions of the atoms. A widening of the lines may be produced at a higher temperature by the backward and forward motions of the molecules in the direction of the observer. A widening of the lines may also be produced by increase of pressure, because it diminishes the free path of the molecules, and the disturbances of the ether arising from collisions become more important than vibrations arising from the regular vibrations of the atoms. Band spectra, or channelled space spectra, more readily occur in the case of bodies which are not very readily subject to chemical actions, or, according to Professors Liveing and Dewar, in the case of cooler vapours near the point of liquefaction.

The effects of change of temperature on the character of spectra is very well illustrated by an experiment of M. Wiedemann with mixtures of mercury with hydrogen or nitrogen in a Geissler's tube. At the ordinary temperature of the air the spectrum of hydrogen or nitrogen was obtained alone; but on heating the tube in an air-bath the lines of mercury appeared and became brighter as the temperature rose, and at the same time the hydrogen lines disappeared in the wider portion of the tube and at the electrodes. The hydrogen or nitrogen lines disappeared first from the positive electrode and in the luminous tuft, and as the temperature rose disappeared altogether. With nitrogen in a particular experiment, up to 100° C., the nitrogen lines were seen throughout the tube, but from 100° to 230° the nitrogen lines appear towards the negative pole, and the mercury lines are less bright at the negative than at the positive pole, while about 230° C. no nitrogen lines appear. The experiments of Roscoe and Schuster, of Lockyer and other observers, with potassium, sodium, and other metalloids in vacuum tubes, from which hydrogen is pumped by a Sprengel pump, also show great changes in the molecular condition of the mixture contained in the tubes when they are heated to different temperatures. The changes of colour in the tube are accompanied by changes in the spectrum. Thus, Lockyer finds that when potassium is placed in the bottom of the tube, and the spark passes in the upper part of it, as the exhaustion proceeds and the tube is slightly heated, the hydrogen lines disappear, and the red potassium line makes its appearance; then as the temperature is increased, the red line disappears, and three lines in the yellowish-green make their appearance, accompanied by a change in the colour of the tube, and at a higher temperature, and with a Leyden jar joined to a secondary circuit of the induction coil, the gas in the tube becomes of a dull red colour, and with this change a strong line comes out in the spectrum, more refrangible than the usual red potassium line. In this case, on varying the conditions, we get a variation in the character of the spectrum, and the colours and spectra are different in different parts of the tube. In Lockyer's experiments, at the temperature of the arc obtained from a Siemens' dynamo-machine, great differences appear in different parts of the arc; for instance, with carbon poles in the presence of calcium, the band spectrum of carbon, or the carbon flutings and the lines of calcium, some of them reversed, are seen separated in the same way as mercury and hydrogen, the carbon spectrum appearing near one pole and the calcium near the other, the lines which are strongest near that pole being reversed or absorbed by the quantity of calcium vapour surrounding it. On introducing a metal into the arc, lines appear which are of different intensities at different distances from the poles, others are strong at one pole and entirely absent at or near the other, while some lines appear as broad as half-spindles in the middle of the arc, but are not present near the poles. Thus, the blue line of calcium is visible alone at one pole, the H and K lines without the blue line at the other.

We may probably regard these effects as the result, not of temperature alone, but must take into account that we have powerful electric currents which will act unequally on the molecules of different bodies according as they are more or less electro-positive. It would seem that we have here something analogous to the segregation which is observed in the melting of certain alloys to which I have already referred.

The abundance of material in some parts of the arc surrounding the central portion of it gives rise to reversal of the principal lines in varying thicknesses over the arc and poles, so that bright lines appear without reversal in some regions, and reversals or absorption lines without bright lines in others. The introduction of a substance into the arc gives rise to a flame of great complexity with regard to colour and concentric envelopes, and the spectra of these flames differ in different parts of the arc. Thus, in a photograph of the flame given by manganese, the line at wave-length 4234·5 occurs without the triplet near 4030, while in another the triplet is present without the line 4234·5.

The lines which are reversed most readily in the arc are generally those the absorption of which is most developed in the flame; thus the manganese triplet in the violet is reversed in the flame, and the blue calcium line is often seen widened when the H and K lines of calcium are not seen at all. In consequence of the numerous changes in spectra at different temperatures, Mr. Lockyer has advanced the idea that the molecules of elementary matter are continually being more and more broken up as their temperature is increased, and has put forward the hypothesis that the chemical elements with which we are acquainted are not simple bodies, but are themselves compounds of some other more simple substances. This theory is founded on Mr. Lockyer's comparisons of spectra and the maps of Angstrom, Thalèn, Young, and others, in which there are coincidences of many of the short lines of the spectra of different substances. These short lines are termed basic lines, since they appear to be common to two or more substances. They appear at the highest temperatures when the longest lines of those substances and those which are considered the test of their presence are entirely absent.

Mr. Lockyer draws a distinction between weak lines, which are basic, *i.e.*, which would permanently exist at a higher temperature in a more elementary stage, and other weak or short lines which would be more strongly present at a lower temperature, in a more complex stage of the molecules. Thus, in lithium, the red line is a low temperature line, and the yellow is feeble; at a higher temperature, the red line is weak, the yellow comes out more strongly, and the blue line appears; at a higher temperature still, the red line disappears, and the yellow dies away; whilst at the temperature of the sun the violet lithium line is the only one which comes out strongly. These effects are studied by first producing the spectrum of the substance in the Bunsen flames, and observing the changes which are produced on passing a spark through the flame; thus, in magnesium a wide triplet or set of three lines (5209·8, $b^1$ and $b^2$) is changed with a narrow triplet ($b^1$, $b^2$, and $b^4$) of the same character. We have here what some observers regard as a recurrence of the same harmonic relation of the vibrations of the same body at a higher temperature.

If the so-called elements are compounds, they must have been formed at a very high temperature, and as higher and higher temperatures are reached the dissociation of these compound bodies will be effected, and the new line spectra, the real basic lines of those sub-

stances which show coincidences, will make their appearance as short lines in the spectra. In accordance with this view, Mr. Lockyer holds that the different layers of the solar atmosphere may be regarded as a series of furnaces, on the hottest of which, A, we have the most elementary forms of matter capable of existing only in its uncombined state; at a higher and cooler level, B, this form of matter may form a compound body, and may no longer exist in a free state at the lower temperature; as the cooler and cooler levels, C, D, and E, are reached, the substances become more and more complex and form different combinations, and their spectra become altered at every stage. Since the successive layers are not at rest, but in a state of disturbance, we may get them somewhat mixed, and the lines at the cooler levels, D and E, may be associated with the lines of the hotter levels; these would be basic or coincident lines in the spectra of two different compounds which exist at the cooler levels, D and E. We might even get lines which are not present in the hottest furnace, A, coming into existence as the lines of compounds in B or C, and then extending among the lines belonging to more complex compounds which can only exist at a lower temperature, when they might be present as coincident weak lines in the spectra of several compound bodies. Thus Mr. Lockyer regards the calcium lines, H and K, of the solar spectrum as evidence of different molecular groupings of more elementary bodies. In the electric arc with a weak current the single line 4226 of calcium, which is easily reversed, is much thicker than the two lines H and K; but the three lines are equally thick with a stronger current, and are all reversed. With a spark from a large coil and using a condenser the line 4226 disappears, and H and K are strong lines. In the sun, the absorption bands, H and K, are very broad, but the band 4226 is weak. Professor Young, in his observation of the lines of the chromosphere, finds that H and K are strongly reversed in every important spot and in solar storms; but the line 4226, so prominent in the arc, was only observed three time in the chromosphere.

One of the most interesting features among the most recent researches in Spectrum Analysis is the existence of rhythm in the spectra of bodies, as has been shown by M. Mascart, Cornu, and others, such as the occurrence and repetition of sets of lines, doublets, and triplets in the spectra of different substances and in different parts of the spectrum of the same body. Professors Liveing and Dewar, using the reversed lines in some cases for the more accurate determination of wave-lengths, have traced out the rhythmical character in the spectra of sodium, potassium, and lithium. They show that the lines of sodium and potassium form groups of four lines each, which recur in a regular sequence, while lithium gives single lines, which, including the green line, which they show really to belong to lithium, though it was ascribed to cæsium by Thalén, also recur in a similar way. In these three metals the law of recurrence seems to be the same, but the wave-lengths show that the whole series are not simple harmonies of one fundamental, although between some of the terms very simple harmonic relations can be found. Between the lines G and H are two triplets of iron lines, which, according to Mr. Lockyer, do not belong to the same molecular grouping as most of the other lines. In many photographs of the iron spectrum these triplets have appeared almost alone. Also the two triplets are not always in the same relation as to brightness, the more refrangible being barely visible with the spark; combining this with Young's observations, in which some short weak lines near G appear in the chromosphere 30 times, while one of the lines of the less refrangible triplet only appears once, and with the fact that in the solar spectrum the more refrangible triplet is much the more prominent of the two, Mr. Lockyer is led to the conclusion that these two triplets are again due to two distinct molecular groupings. There is one difficulty which must be taken account of in connection with Mr. Lockyer's theory with regard to the production of successive stages of dissociation by means at our command: (1) by combustion of different substances; (2) by an electric arc, which will probably give slightly different temperatures according as it is produced by different dynamo-electric machines; (3) by the induction spark without; and (4) with a condenser.

*(To be continued.)*

## AN IMPROVED ELECTRO-MOTOR.

By T. WIESENDANGER.

(Read before the British Association, August 31, 1880.)

THE powerful impulse given to scientific research and inventive effort by the rapid progress in the development of the electric light, during the last two years, has produced the most promising results with regard to the production and employment of powerful electric currents for practical useful purposes. In these results, as already achieved, the scientific mind cannot fail to detect the embryo of a grand system of production and transmission of energy through conversion of forces, which is to supersede, in times to come, the means and methods at our command, in the present century, for generating energy through combustion. Remote as the date may be, when the vast accumulations of coal which now serve to impart life to our prime-motors shall all be consumed and the mines all exhausted, yet that epoch will and must come, as surely as our supply of combustible fuel is limited—as surely as we now consume the light and heat-producing carbons in a manner both wasteful and thoughtless. Numbers of coal-mines in this country are already abandoned, their resources being exhausted; and when the last of them is delivered up to that destruction which is brought about by time—wrought by oxidation, slow and "sure"—an important problem has to be solved: Science must then have discovered new principles, have invented new methods and novel appliances able to supersede the agencies at work in the present era, to cheer our homes with light and heat; to supply us with the vast motive energy that gives life to the thousand living mechanisms of our industries and factories.

Perhaps it is natural that our present generation should find it difficult to disassociate the idea of the generation of caloric luminous and motive energy from that of combustion, the rapid oxidation of fuel, and that the solution of the problem spoken of above is sought merely in the substitution of the consumption of a carbonaceous matter by that of some other substance.

There are powers at our command already by means of which motive energy, light, and heat can be obtained and transmitted to considerable distances; and the scientific mind has found indications, sure and certain, which create a conviction that, as the secrets of these forces are investigated, and are more and more brought to light, so the transmission of heat, as well as that of luminous and motive energy, will no longer be limited by space. Electric currents, of almost any power, can be, and are now, both naturally and by artificial means, produced independent of either slow or rapid oxidation. The friction created by wind and water—the action upon each other of different parts of the globe—

frequently have excited powerful currents of electricity unknown to and left unemployed by the human race. The tides that sweep our shores and ascend our rivers, are another grand creative source of motive energy unlimited, unemployed, and idle. Could this fertile source of energy be utilised, the difficulties in our way can be surmounted, and the energy thus obtained may, with little loss, be converted into electric currents but little limited by distance; currents powerful enough to melt our steel, to illuminate our public promenades and streets, to plough our very fields, and give life to the iron sinews of our innumerable factories.

Attempts have been made in this country to transmit the power of a waterwheel, driven by a waterfall, through the agency of the conversion of forces. A well-known gentleman succeeded, by these means, in lighting his library, and in driving machinery stationed at a very considerable distance from the prime source of energy. It was found, however, that further researches, and new discoveries and inventions, require to be made before the same process can be extensively applied to practical useful purposes.

Since then, a similar project, but on a scale far larger, has been undertaken and is being carried on in America, and should it finally prove a success, it is proposed to employ the Falls of Niagara as the central source of motive power for all the neighbouring country.

All the results hitherto obtained point to the fact, that one of the greatest difficulties met with in this field of work is the inefficiency of the dynamo-generators, and especially of the electro-motors of our present time, together with our, as yet, imperfect and fragmentary knowledge of electrical energy.

The greater the number of improvements made in the construction of the former machines, and the more deeply our scientific investigators penetrate into the secrets of this subtle force, the less remote will be the time when the transmission of motive power, light, and heat, will triumph over its greatest enemy, distance.

While recently many minds have been at work, with more or less of success, to produce improvements in dynamo-generators of electric energy, very few have given their special care and attention to the development of the electro-motor. Engineering science has taught us hitherto that the efficiencies of one and the same machine for action and reaction, or for use, either as a generator or by the inverted process as an electro-motor, stand in a certain and direct proportion to each other; or that our most efficient generators, such as the Siemens, Brush, and Gramme machines, prove also the most effective motors; and, on the other hand, that inferior dynamo-machines invariably are inefficient motors. From the results of researches I have recently made, I have come to the conclusion that the motors which are to supersede those now in use could not be employed as generators. Dynamo-machines, such as now constructed, only prove efficient when their field-magnets are able to retain, at all times (*e.g.*, even when the machine stands at rest), a certain and very considerable amount of residual magnetism, and for that reason their cores are made of retentive material—hard cast-iron—as is the case in the Brush and Gramme machines; or if the cores consist of soft iron, they are attached to large masses of hard cast-iron in such a manner that the latter are inclosed in the magnetic circuit and form part of the cores.

Generators of the same kind, when made small in size, have cores much larger and heavier in proportion; and, moreover, the base-plate, or, as in the Weston machine, a heavy retentive cylinder, is made to form a portion of the field-magnets.

But all effort hitherto made to produce efficient small dynamo-machines with cores of soft iron only, have resulted in absolute failure, although men of the highest genius have made repeated and prolonged efforts to solve that most difficult of problems.

These curious facts conclusively prove that the theory explanatory of the action of dynamo-machines, as now universally adopted, viz., the theory of inductive action and reaction between the field-magnets and the armature, cannot any longer be considered complete or satisfactory; for even wrought iron, especially when occurring in large masses, always contains an appreciable amount of residual magnetism, more especially after it has once been subjected to strong magnetisation; and if the above theory were correct and complete, then the smallest possible amount of residual magnetic energy, augmented by repeated action and reaction, would be sufficient for the starting of such a machine to action. This, however, experience proves *not* to be the case, and the theory, although stoutly adhered to, must be either abandoned or amended.

The inventors of the most recent electro-motive engines have worked, perhaps unconsciously, upon the idea that the construction and action of electro-motors are based altogether upon the same laws as those of dynamo or magneto-machines, and, in accordance with that assumption, the field-magnets of the Deprez motor are made to consist of large and heavy masses of magnetised sheet.

Experimenters have also for a long time past clung to the idea that the efficiency of an electro-motor, or the amount of energy to be obtained from such a machine by means of a current of given strength circulating in the coils of its armature only, bears a definite and direct proportion to the magneto-inductive power of its field-magnets, and that an increase of power in the field-magnets alone must necessarily produce greater capabilities of the machine. This is a mischievous theory and erroneous in its very principles, and its development would only lead to the hypothesis of perpetual motion. On the contrary, starting from a consideration of the fact that a very small magnetic needle, if acted upon by one of the poles of another and very powerful magnet, has its polarity destroyed or reversed, and that if one of its poles, say the N pole, is presented to a similar (N) pole of the large magnet, the former will completely lose its attracting qualities and be attracted by its overpowering opponent, one can only come to the one natural conclusion—that the power of the field-magnet for electro-motors, as compared to that of the magnet or magnets constituting the machine, should vary as the limit of some certain ratio, to be determined yet by experiments carefully conducted, and that if we pass that limit the capabilities of the machine must be impaired. Acting on this principle I have constructed a machine in which the power of the field-magnets is as nearly as possible equal to that of the armature. The cores of the former are very light, and are made entirely of soft iron, and the satisfactory results obtained from this machine are a sure sign that further investigation on the subject and improvements made with the view of determining the proportion of power between the magnets and armature will result in further improvements.

Another and very important consideration in the construction of dynamo-machines and electro-motors has not yet received that care and attention from scientific investigators which would lead to immediate progress. It is the method of motion of the revolving armature with regard to its approaching to, or receding from, the poles of the field-magnets. In nearly all the machines now constructed the polar faces of the cores of the field-magnets, and those of the armature, are of such a shape, and the latter is caused to revolve in such a manner, that

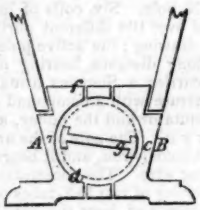


FIG. 1

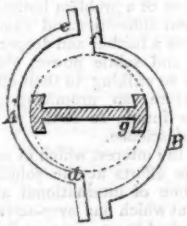


FIG. 2.

FIG. 3.

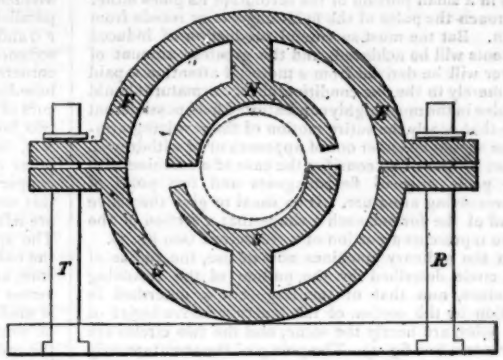


FIG. 4.

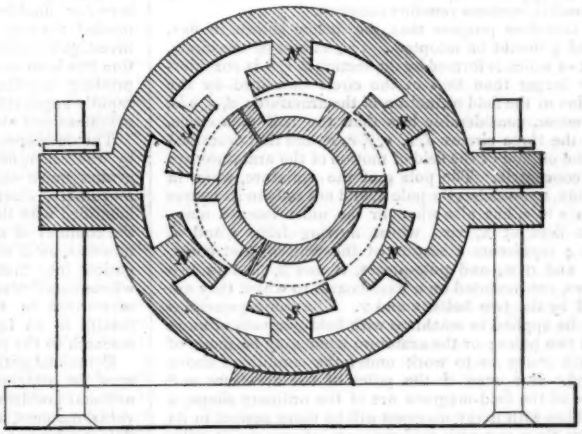


FIG. 5.

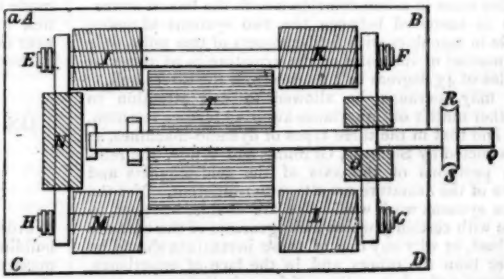


FIG. 6.

only in a small portion of the revolution its poles either approach the poles of the field-magnets or recede from them. But the most successful production of induced currents will be achieved, and the greatest amount of power will be derived from a motor, if attention is paid not merely to the *one* conditionthat the armature should revolve in the most highly concentrated field possible, but also that nearly the entire motion of the revolving armature should be either one of approach or of withdrawal.

Let us first of all consider the case of a machine with two poles only of field-magnets and two poles of the revolving armature. It is usual to give the active facial of the former such a shape that a section of the same represents a portion of a true circle (see fig. 1).

In the ordinary machines now in use, the radius of the circle described by the outline of the revolving armature, and that of the large circle, described in portion by the section of the inner or active facial of the poles, are nearly the same, and the two circles are concentric (see fig. 1). The pole *g* of the armature only approaches the pole A of the field-magnet while moving from *c* to *d*, or where the intensity of the magnetic field of A is at its minimum. When continuing its motion from *d* to *r* and to *f* the pole *g* can no longer be said to approach A, because the distance between the respective surfaces remains constant.

I therefore propose that the device shown in figs. 2 and 3 should be adopted. The radius of the circle, part of which is formed by the section *d*, *r*, *e*, is considerably larger than that of the circle described by the outline of the field of motion of the armature; *d*, *r*, *e* is, moreover, considerably less than the half of a circle, and the three circles *d*, *r*, *e*, *f*, *e*, *g*, and that described by the outline of the field of motion of the armature, are *not* concentric. The pole *g* of the armature, when in motion, approaches the pole A, and not only in its course from *e* to *r*, but also when in the most intense magnetic field of A, viz., whilst moving from *r* and *d*. Fig. 4 represents a section of the field-magnet cores, E F and G H, and pole-pieces, N and S, cast in two halves, are mounted on a base-board, to which they are fixed by the two bolts, R and T. The same principles may be applied to machines with field-magnets of more than two poles; or the armature itself may be made of such a shape as to work under the conditions above stated. But even if the poles of the armature and those of the field-magnets are of the ordinary shape, a machine with many magnets will be more perfect in its action than one with field-magnets of two poles only. Fig. 5 illustrates a machine in which the armature during nearly the whole of its motion either approaches to, or recedes from, the poles of the field-magnets. In such machines the motion of the poles of the armature is also more in a line coincident with the line of attraction as exercised between the two systems of poles, while in machines with field-magnets of two poles only the motion of the poles of the armature is at times at angles of 45 degrees to 1 degree from the direct pull.

I may, perhaps, be allowed to call attention to another matter of importance awaiting further research. We find that in the three types of dynamo-machines, as constructed by Siemens, Gramme, and Wilde, the relative positions of the axis of the field-magnets and those of the armature are altogether different. Yet the three systems work well. We are unable, however, to state with certainty which arrangements of the axis are the best, or why any one of these inventions should be better than the others, and, in the face of experience, the theory of tubes or lines of force is little more than a hypothesis with all its diffusion, vagueness, and uncertainty.

Having so far considered general principles chiefly, I now beg to describe this motor. A B C D (fig. 6) is a wooden base-board, E F G H a frame, consisting of the two parallel round rods, F E and G H, and the two flat bars, F G and E H, made of the best wrought iron and carefully softened. The four bars are screwed together at the corners and supported by four brass brackets over the base-board. These four iron rods form the compound core of the field-magnets, a combination, as it were, of two horseshoe magnets, whose similar poles, S S and N N, form the junctions, thus we have practically two poles only, a S and a N pole. Six coils of insulated copper wire are wound over the different portions of this core, shown in the drawing; the active pole-pieces are left exposed for a long distance, bearing no coils. The spindle Q, which carries a Siemens armature of the old form, or an armature with a compound tubular core, and also the commutator and the pulley, R S, traverses the flat cross bar F G. The core of the armature is made of sheets of charcoal-iron, and it bears a coat of stout insulated copper wire. The commutator is of the ordinary kind, consisting of two half-tubes of brass, insulated from each other and from the spindle, and each forming one of the terminals of the coil.

The development of most important machines is destined to reach a certain stage of perfection when further improvements cannot be accomplished by the inventor unaided, the second and important factor needed then is the co-operation of inventive and investigative talent with capital. This stage of perfection has been reached in the steam engine, gas engines, printing machinery, &c., and it may be said to be rapidly approached by the progress made in dynamo-machines and electro-motors.

The development of the latter machines is followed by the scientific world with greater interest, and it evokes more eager expectations than that of other machinery, chiefly because it is not and cannot be identified with the solution of a problem limited within the confines of mechanical difficulties and commercial interests, but it necessitates a further and deeper investigation into that great and subtle power, electricity, whose manifestations are so striking in their effects, so mysterious in their nature, so promising of great results in an immediate future, so fertile a field of research to the pioneer of science.

Combined with this is the interest which of necessity must be attached to the efforts at the solution of a national problem, nay, one of international and universal moment, and one at which our ever-active trans-Atlantic kinsman has worked to so great credit. Who will be the winner in this meritorious competition? Of higher moment even than the answer to this question ever can be is the consideration that by the work done in trying to solve the great problem, new efforts will be made in scientific research, new principles discovered, new inventions made, and more light will be thrown over fields of intellectual work hidden, even now, in darkness, doubt, and mystery.

## ON THE PROPER FORM OF LIGHTNING CONDUCTORS.

By WILLIAM HENRY PREECE.

(Read before the British Association, Aug. 27, 1880.)

A LIGHTNING conductor erected for the protection of a building consists of a ribbon, rod, chain, rope, or other mass of metal attached to the highest point of the structure, and descending to the earth. What shall be the form of this conductor? has been a vexed question from the days of Franklin to the present. Shall it be dependent on extent of surface or on sectional area? In other words, does the transference of electricity

when the potentials are so high as to cause lightning discharges, obey the law of Ohm, or is this law modified by the presence of some fresh condition? Snow Harris was a very warm advocate of the surface form. He used flat ribbons for his ships, and tubes for his buildings. Henry, of Washington, believed in the efficacy of surface. According to him, frictional electricity passes at the surface, galvanic electricity through the mass.* M. Melsens is found on the same side, and Guillemin, of Paris, led many French electricians to favour the same view.

On the other hand, Faraday almost angrily espoused the opposite side. "As respects electrical conduction," said he, "no advantage is gained by expanding the rod horizontally into a strap or tube. Surface does nothing; the solid section is the essential element."

The advocates of the solid and cylindrical form argue that the lightning conductor is simply a path by which electricity is transferred from a point of high potential (an electrified cloud) to a point of lower potential (the earth), and that its efficacy depends solely upon its resistance. It obeys the law of Ohm, and its efficacy is therefore for the same material dependent on its mass and sectional area.

The advocates of surface argue, that as in all cases of static charge electricity exists only on the surface, so when electricity of "high tension" is conducted away it is the surface that plays the prime part, and, therefore, the greater the surface the easier the path to the discharge. Again, they say when a cylindrical conductor conveys a charge of electricity it is raised to a "high tension," and is rendered capable of doing mischief; but with the same charge, the greater the surface the less the density on the surface, and, therefore, the greater the safety. In other words, with a given quantity of electricity, the greater the surface the less the potential. Moreover, they urge, since according to Guillemin currents of electricity flowing in the same direction retard each other with a power varying with the distance separating them, and since a rod may be considered as a bundle of smaller but parallel rods, so a current of electricity may be considered as being made up of many parallel currents, each retarding the other. Hence, a ribbon will conduct better than a rod, because the currents are spread further apart, and retard each other less. These arguments have led to the employment of unsightly ribbons and expensive tubes, which have considerably interfered with the establishment of this very necessary element of safety to buildings.

The arguments in favour of the surface form are, in the opinion of the author, deductions from exploded theories, from imperfect experiments, or from erroneous interpretations of well-ascertained facts. No direct experiments have ever been made to solve the question, as far as the author knows. Quantities of electricity, that is, static discharges from condensers, are in incessant use for telegraphic purposes, and are found to follow exactly Ohm law, even with the most delicate apparatus. The knowledge of the flow of electricity through conductors, of the retarding influence of electrostatic capacity upon this flow, and of the distribution of charge, has become so much greater of late years through the great extension of submarine telegraphy and the labours of Sir William Thomson, Clerk-Maxwell, and others, that I question if any English electrician would now be found to argue in favour of the surface form. Nevertheless, ribbons and tubes still continue to be used, and it appeared very desirable to settle the question experimentally. I determined to try and do so.

* *Telegraphic Journal*, October 15th, 1877.

*First Experiments, June* 28, 1880.

Dr. Warren de la Rue, who is always ready to place his splendidly equipped laboratory at the service of science, not only allowed me to use his enormous battery and his various appliances, but aided me by his advice, and assisted me in conducting the experiments.

Copper conductors, 30 feet long, of precisely the same mass (*a*), drawn into a solid cylinder (*b*) made into a thin tube, and (*c*) rolled into a thin ribbon were first of all obtained. The source of electricity was 3,240 chloride of silver cells. The charge was accumulated in a condenser of a capacity of 42·8 microfarads. It was discharged through platinum wire of ·0125 diameter, of different lengths. The sudden discharge of such a large quantity of electricity as that contained by 42·8 mf. raised to a potential of 3,317 * volts is very difficult to measure. It partakes very much of the character of lightning. In fact the difference of potential per unit length of air is probably greater than that of ordinary lightning itself. It completely deflagrates 2½ inches of the platinum wire, but by increasing the length of the wire it could be made to reproduce all the different phases of heat which are indicated by the various shades of red until we reach white heat, fusion, and deflagration. Hence the character of the deflagration, which is faithfully recorded on a white card, to which the wire is attached, by its scatttered particles, is a fairly approximate measure of the charge that has passed, while the length of wire, raised to a dull red heat is a better one, for any variation in the strength of the current within moderate limits is faithfully recorded by the change of colour.

Experiment 1.—Similar charges were passed through the ribbon, tube, and wire, and in each case 2½ inches of wire were deflagrated. No difference whatever could be detected in the character of the deflagration.

Experiment 2.—Ten inches of wire were taken and similar charges passed through. In each case the wire was raised to very bright redness, bordering on the fusing point, and in two cases the wire broke. In each case the wire knuckled up into wrinkles, and gave evidence of powerful mechanical disturbance. The same wire was not used a second time. No difference could be detected in the effect through the different conductors.

Experiment 3.—Silver wire of the same diameter and length was used, and similar charges transmitted through it. Redness was barely visible, but the behaviour of the wire was similar in each case.

The conclusion arrived at unhesitatingly was that change of form produced no difference whatever in the character of the discharge, and that it depended simply on mass.

*Second Experiments, July* 19, 1880.

As it might be urged that the length of conductor tested was so short, and its resistance so small that considerable variations might occur and yet be invisible, similar lengths (30 feet) of lead—a very bad conductor, its resistance being twelve times that of copper—were obtained, drawn as a wire, made as a tube, and rolled as a ribbon, each being of similar weight.

Experiment 4.—Charges from the same condenser, 42·8 mf., but with 3,280 cells, were passed through, and the discharges observed on 6 inches of platinum wire 0·0125 inches diameter, which in each case was heated to bright redness. No variation whatever could be detected, whether the wire, the tube, or the ribbon were used.

* The electro-motive force of the chloride of the silver cell is 1·03 volt.

Experiment 5.—In order to form some idea as to how closely we could estimate any variation in the character of the discharge, we used a long piece of platinum wire and adjusted the lengths until we obtained just visible redness; then a diminution of 10 per cent. (3 feet) produced a marked change to dull redness, and further excisions raised the temperature to brighter and still brighter red.

The conclusion arrived at was that any change in resistance of 5 per cent. would have been clearly and easily discernible.

It therefore appears proved that the discharges of electricity of high potentials obey the law of Ohm, and are not affected by change of form. Hence, extent of surface does not favour lightning discharges. No more efficient lightning conductor than a cylindrical rod or a wire rope can therefore be devised.

## ELECTRIC MINE EXPLODERS.

### SIEMENS' APPARATUS.

(*Continued from page* 275.)

*The small quantity-exploder* is of the same construction as the large one, but its weight, including knapsack, is only 39 lbs. It fuses a quarter of an inch of 0·0015 inch iridio-platinum wire through a line resistance of 50 Siemens' units. With short leading-wires this exploder heats 8¾ inches of iridio-platinum wire of 0·0015 inch diameter, which is equal to about 35 Service Detonators, No. 13. Dimensions of the exploder, 12″ × 11″ × 6″.

With a given electro-motive force the quantity of current passing through a circuit per unit of time depends upon the resistance of the circuit, hence, if only one quantity-fuse be connected up with the exploder, a stronger current will be generated than when several fuses are joined in series. Thus, with a small exterior resistance, a large quantity of current passes from the armature into the electro-magnets of the machine, whereby a very powerful magnetic field is formed and the revolving armature experiences a resistance to its motion, which may become so great as to render the turning of the handle of the machine difficult. In order to overcome this inconvenience as much as possible, an extra coil of several units resistance is inserted in the base of the instrument. This extra coil may be increased in resistance 10 or 20 units if the machine be required to turn with greater ease. When the firing-key is at rest, the extra coil is in circuit with the electro-magnet coils, but when the key is depressed the extra coil is cut out, and the line and fuses put in circuit.

The only reliable test of the efficiency of tension-exploders is length of spark, as, owing to the great difference in the resistance of tension-fuses, any standard of efficiency based upon the number of such fuses an exploder will fire must be incorrect. The test for the quantity-exploder is the length of iridio-platinum wire of a standard diameter which can be fused.

The nature of electricity of great electro-motive force, by which it overcomes high resistances, requires that the coating of the cable or conducting wire should have high resistance, or, in other words, be well insulated, in order to prevent escape of the electric current. It should be borne in mind that to "insulate a wire" means to surround the wire with a covering which offers sufficient resistance to the escape of the electric current, and, consequently, that the greater the electro-motive force the greater is the resistance required in the insulating covering.

In cases where the conducting wires are for the greater part of their length stationary, high tension electricity is to be preferred, because its greater power of overcoming resistance enables it to fire a larger number of fuses through longer distances. On this account the tension-exploder is better suited to mining purposes, where fuses have to be exploded either in numbers *simultaneously* or through *long* circuits.

But in cases where only short lengths of conducting wires are employed, and these are frequently shifted or subjected to such rough usage as would endanger the insulation of the cable, the use of electricity of *small* electro-motive force is advisable, for this will pass without loss through a cable with faults in the insulation through which currents of greater force would readily escape. On this account the quantity-exploder should be employed.

The mistake of using weak machines has done much to hinder the adoption of electrical firing.

The dynamo-exploders are unquestionably the most suitable for blasting, and of the two kinds of apparatus the tension-exploder is usually preferred in consequence of tension-fuses being cheaper than platinum wire-fuses. When, however, a system of mines has to remain a long time inoperative, and yet in a condition to be fired at a moment's notice, daily electrical tests must be taken, and this can only be done when platinum wire-fuses are used.

There are two kinds of fuses adapted to the two kinds of electric-exploders, viz. :—

(*a*) Tension fuses.

(*b*) Quantity fuses.

Tension-fuses should be made of stable elements, so that no chemical decomposition can take place in the priming, and the fuses must remain unaffected by moisture and heat, even when used in tropical climates. The composition of tension-fuses should likewise keep unchanged during a long sea voyage, as many failures in electric blasting abroad have been due to a chemical change in the fuses or to the mass of the priming having become loosened during transport. It is important, in connecting up the fuses in circuit for firing, that great care should be taken not to put too much strain upon the fuse wires, otherwise these wires are apt to be pulled out of the explosive compound, and the fuse cannot then explode. The data given below respecting the number of fuses fired by Siemens' exploders refer to Abel's fuses only.

When a number of fuses are joined in single circuit the resistance of each fuse is added to that of the entire circuit, but when connected in divided circuit the joint resistance of the fuses is less than that of a single one only. In cases where an unusually large number of *tension-fuses* are required, the *divided circuit* may be used, but the connections are *troublesome* to make, and as a sufficient number of fuses can be fired in *single* circuit, this latter

method is preferable for quantity as well as tension-fuses.

The following are some results obtained with the large dynamo-electric exploders :—

Fuses connected in single circuit.

Fifty fuses fired with large tension-exploder.

Fuses arranged in divided circuits, three groups of six fuses each. (Fig. 4.)

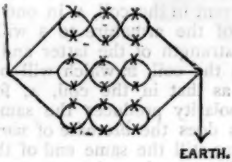


FIG. 4.

All eighteen fuses fired with large tension-exploder.

Fuses arranged in three groups of ten. (Fig. 5.)

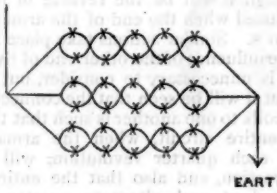


FIG. 5.

All thirty fuses fired with large tension-exploder.

Fuses arranged in fourteen groups of five each. Sixty-one fired out of the seventy.

*Single fuse firing* with platinum wire-fuses.

One fuse of wire 0·03 mm. diameter exploded through 140 Siemens' units resistance, with large quantity-exploder.

*Fuses connected in single circuit :—*

Forty-four service detonators, No. 13, exploded with large quantity-exploder.

Thirty-four service detonators, No. 13, exploded with small quantity-exploder.

The heating power of the large quantity-exploder is such that, with a platinum-wire weighing 1·65 grains per yard, 6½ inches can be fused on short circuit and 14 inches were heated to redness.

If more than one charge is to be exploded, three or four tension-fuses may be placed in each, and the groups of fuses connected to the main leading wires in the manner shown in fig. 6, which shows three groups. But care should be taken not to place more fuses in circuit than the apparatus can with certainty explode.

If only one charge is to be exploded, the fuses should be connected up in single circuit, so that the current may pass through one fuse after the other.

The earth may be used in place of one of the leading-wires. In this case it is necessary to provide two *earth-plates*, one of which is to be buried in *damp* earth near the mine to be exploded and connected by a wire with the fuse, the other to be buried near the machine and connected by a wire with one of the connecting screws, *e*. The earth-plates should measure at least 3 ft. by 2 ft., and be of copper. If the earth is not naturally moist it must be made so with water; but, as a rule, *earth-plates are not recommended* for the return of the current, owing to the difficulty of getting a reliable earth-connection which will not considerably increase the electrical resistance of the circuit.

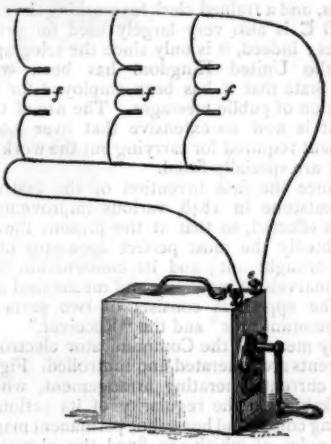


FIG. 6.

In the case of a cable having a metallic sheathing, this latter may be used instead of earth-plates as a return wire; care must, however, be taken to make good metallic connection with the wires which connect the cable sheathing to the fuses and to the machine.

The leading-wire or cable conductor, best adapted to the various kinds of work to which the exploders are more generally applied, consists of a three-strand tinned copper wire, insulated with three layers of india-rubber, taped with cotton saturated with india-rubber, of which fig. 7 is a section.

FIG. 7.

FIG. 8.

As the insulation of an unprotected leading-wire is likely to suffer damage from rough usage in mines, an iron sheathed cable is preferred. This consists of a strand of copper wire covered with gutta percha, similar to that just described, also with a serving of tarred jute, and sheathed with iron wires. See fig. 8.

For military and submarine mines the size of the cable required depends very much upon local conditions; a variety of cables are therefore in use.

For connecting the main cable with the fuses and shot-hole wires thin gutta-percha or india-rubber-covered wires are used.

## TELEGRAPHIC APPARATUS IN USE IN THE BRITISH POSTAL TELEGRAPH DEPARTMENT.

### XVI.

### THE A B C INSTRUMENT.

THIS instrument is extensively used at small stations where the amount of traffic is not sufficiently great to warrant the employment of the single needle apparatus, and a trained clerk for working the same. The A B C is also very largely used for private purposes; indeed, it is only since the telegraph system of the United Kingdom has been worked by the State that it has been employed for the transmission of public messages. The use of the instrument is now so extensive that over 5,000 are at present required for carrying out the work for which they are specially fitted.

Since the first invention of the instrument by Wheatstone in 1848, various improvements have been effected, so that at the present time it is undoubtedly the most perfect apparatus of the kind yet brought out; and its construction and action are marvels of ingenuity and mechanical design.

The apparatus consists of two parts—viz., the "Communicator" and the "Receiver."

By means of the Communicator electro-magnetic currents are generated and controlled. Fig. 64 shows the current-generating arrangement, which is remarkable for the regularity of its action. M is a strong compound horseshoe permanent magnet, upon the poles of which are fixed the electro-magnets, A $A_1$ and B $B_1$. The poles of the permanent magnets being set midway on the cross pieces, *b* and *c*, of the electro-magnets, induce in the two soft iron cores of each of the latter, similar and equal polarity—that is to say, the soft iron cores, N $N_1$, of the bobbins, A $A_1$, have similar and equal polarity, whilst the cores, S $S_1$, of the bobbins, B $B_1$, have also similar and equal polarity. But the polarity of the cores, N $N_1$, is the reverse of that of the cores, S $S_1$. In front of, and in close proximity to, the poles of the electro-magnets, a soft iron armature, F F, is placed. This armature is fixed on an axle, *a*, *g*, by means of which it can be rotated. The result of this rotation is as follows:—If an armature is placed on the poles of an ordinary horseshoe permanent magnet, the latter magnetises the armature by induction, and the armature so magnetised reacts back on the poles of the magnet, and increases their power; this increased power in turn reacts back on the armature and increases the power of the latter, and so on. Thus, by a series of reactions, which are almost instantaneous, the magnetic strength of the poles of the magnets becomes considerably increased; or, in other words, the magnetism of the magnet becomes concentrated at the poles. Now, the effect would be the same if the poles were provided with soft iron prolongations. In this case, if the armature were placed on the ends of these prolongations the latter would have a considerable amount of magnetism concentrated on them. On withdrawing the armature, the increase or concentration of the magnetism would cease. If now coils of wire are placed round the prolongations, so that electro-magnets are formed, then the increase and decrease of the magnetic strength will induce currents of electricity in the coils; the direction of the current when the armature is approached being in the reverse direction to that induced when the armature is receded.

In fig. 64 it will be noticed that the armature, F F, is lying in close proximity to the cores, N $S_1$, of the bobbins, A $B_1$. If now F F be rotated a quarter of a circle so as to leave the poles of the cores, N $S_1$, and to cover the poles of the cores, S $N_1$, then the retrocession of the end of the armature from N will weaken the magnetism in the latter, and will induce a current in the coil, A, in one direction; the approach of the armature to S will increase the magnetic strength of the latter and will induce a current in the coil, B, which will be in the *same* direction as that in the coil, A, for *in*crease of *southern* polarity produces the same direction of current as does the *de*crease of *northern* polarity. Considering still the same end of the armature, if the latter be rotated another quarter circle, we shall have the core, S, decreasing in magnetic strength whilst the core, $S_1$, increases in strength, thus S and $S_1$ being of like polarity, the current in the coil, $S_1$, will be in the reverse direction to that in the coil, S, but as the connection between S and $S_1$ is crossed, the current in the circuit will be in the same direction, though it will be the reverse of those which were induced when the end of the armature passed from N to S. Similar actions take place in the coils under the influence of the other end of the armature which it is unnecessary to consider, but if they are traced out it will be seen that the connections of the various coils to one another is such that the currents in the entire circuit, when the armature turns through each quarter revolution, will be in the same direction, and also that the entire direction is reversed at each alternate quarter revolution. By rotating, therefore, F F rapidly, a series of rapidly reversed currents will be sent out by the coils, A $A_1$, B $B_1$.

As the strength of these currents depends upon the degree of change in the magnetic strength in the cores, N $N_1$, S $S_1$, and as this amount of change depends greatly upon the proximity to which the armature, F F, can be brought to the poles of the cores, great care is taken in the surfacing of the armature and the pole faces so that they can be as close as possible in all positions without actually touching.

The magnetic pull on the armature, F F, naturally causes considerable pressure of the end, *g*, of the axle upon its bearing, the latter is therefore jewelled so that as little friction as possible is produced. In order to relieve this pressure and reduce the friction as much as possible, the driving wheel, W (by which the pinion wheel, *w*, fixed on the axis *a*, of the armature, is driven), has its teeth cut diagonally, the teeth of *w* being similarly cut to correspond. The result of this is, that when the wheel, W, is turned in its normal direction, that is, in the direction in which the hands of a watch turn, the inclined teeth tend to make the axle slide away from its jewelled bearing, and thus to take the pressure off. Great ease of turning is produced by this simple device.

#### *The Receiver.*

Before considering how the currents produced from the generator are controlled, and the general construction of the Communicator, it will be as well

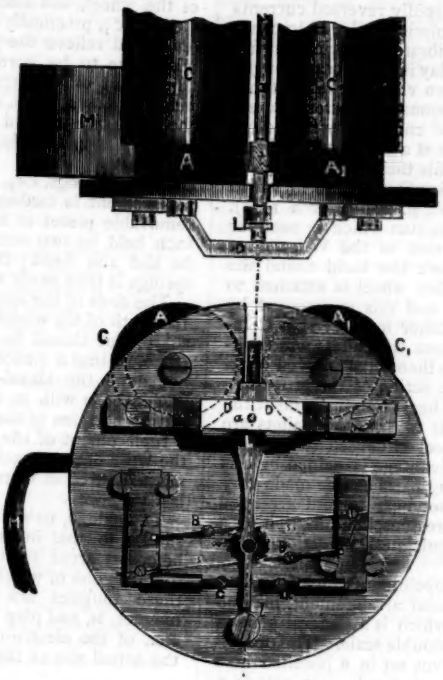


FIG. 66.

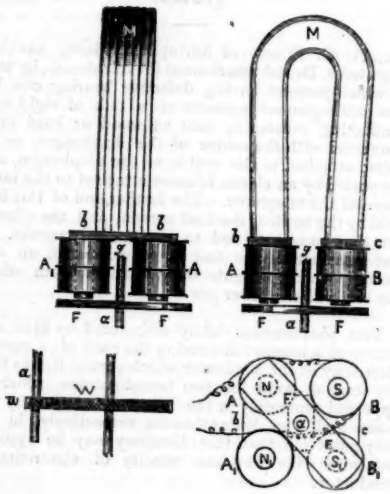


FIG. 64.

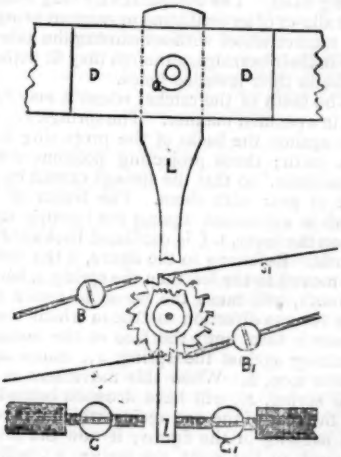


FIG. 65.

to see how the currents can produce the motions of the indicator hand.

The effect of a series of rapidly reversed currents sent through an ordinary polarised relay is to cause the tongue of the latter to vibrate rapidly to and fro. If the construction of the relay is such that its tongue is light, well-balanced, and can vibrate freely without much obstruction, the vibrations will correspond exactly with the succession of currents, even though the latter follow one another at a considerable speed. The form of relay which fulfils these conditions most satisfactorily is the Post Office Standard form, which was described in Article V., p. 101 (March 15th), and it is this form of apparatus which is used for working the receiving portion of the Wheatstone A B C apparatus. To work the hand round the dial, letter by letter, a ratchet wheel is attached to the axle of the dial hand, and this is actuated by spring pallets. In every other form of A B C instrument but the Wheatstone the pallets which actuate the ratchet wheel are themselves moved backwards and forwards by the action of the propelling electro-magnet. In the Wheatstone instrument the reverse is the case, that is to say, the pallets are fixed, and the ratchet wheel is caused to oscillate against them. A great advantage is gained by this arrangement, as the moving parts can be made very light, and their mass be set near to, and arranged uniformly around, the centre of oscillation. This is a very great point when quickness of action is required.

The principle of the propelment, which is an extremely beautiful mechanical arrangement, may be understood from fig. 65, which is a general plan of the mechanism drawn to double scale. The propelling wheel has its axle pivot set in a jewelled hole in the lever, L *l*; this lever is fixed on an axle at *a*, so that it can oscillate between the two limiting screws, C $C_1$. The axle of the ratchet wheel is about 2½ inches long, and its further end passes through a jewelled bearing, and to its end is fixed the indicating hand. The comparatively long length of the axle allows of an oscillating movement being given to the ratchet wheel without causing the axle pivots to jam in their bearings, although they fit without much shake in their jewelled holes.

The teeth of the ratchet wheel it may be seen are cut in a peculiar manner. The springs, *s* $s_1$, normally rest against the backs of the projecting portions of the teeth; these projecting portions are slightly "undercut," so that the springs cannot be jerked up out of gear with them. The fronts of the teeth bank in succession against the limiting stops, B $B_1$, when the lever, L *l*, is oscillated backwards and forwards. Referring to the figure, if the lever, L *l*, be be moved to the left then the spring, *s*, being against a tooth, will cause the wheel to rotate slightly in the reverse direction to that in which the hands of a watch turn, until the face of the tooth which is banking against the spring, $s_1$, comes against the screw stop, B. When this movement is complete, the spring, $s_1$, will have dropped behind the tooth in the rear of the one against which it is represented as banking in the figure; if now the lever, L *l*, be moved to the right the spring, $s_1$, will cause the wheel to rotate a step further until a tooth banks against the screw stop, $B_1$; thus each oscillation causes the wheel to turn through a small angle, the distance actually turned through being equal to half the distance between two teeth. Although the screw stops, B $B^1$, theoretically will limit the motions of the wheel, and also of the lever, L *l*, the screw stops, C $C_1$, practically limit the movements of the lever, and relieve the pressure which would otherwise have to be borne by the teeth alone. The adjustment of the arrangement in, fact, would be made by the springs, *s* $s_1$, and the screws, B $B_1$, in the first instance, and then the screws, C $C_1$, would be set so as to slightly lessen the play of the end of the lever.

As the springs, *s* $s_1$, occasionally get broken their replacement is facilitated by having them fixed to removable pieces of brass, *f* $f_1$, (fig. 66), which are each held by two screws, between which they can be slid and fixed; the correct adjustment of the springs is thus easily made.

The ends of the springs, *s* $s_1$, which bank against the teeth of the wheel should not be left jagged or sharp, but should be carefully rounded on an oil-stone, so that a smooth end is produced; if this is not done the chisel-like action of the sharp or jagged ends will, in a short time, cut off the projecting portions of the teeth of the wheel, rendering a replacement of the latter necessary. To render the wear of the wheels as small as possible they are manufactured of German silver, which is found to last very well.

The axle, *a*, to which is secured the lever, L *l*, is similar to that in the Post Office Standard relay before referred to, being provided with soft iron tongues, one of which, *t*, can be seen in the figure; these tongues are polarised by the permanent magnet, M, and play between the pole pieces, A $A_1$, &c., of the electro-magnets, C $C_1$. Fig. 66 shows the actual size of the mechanism.

## Notes.

MR. H. C. FISHE, of Springfield, Mass., has lately patented a Dental attachment for telephones, by means of which persons having defective hearing can hear. The arrangement consists of a link of rigid sound-conducting substance, such as wood or hard rubber, connected with the centre of the diaphragm, or with a disc attached to the centre of the diaphragm, and is supported by an elastic fulcrum attached to the mouthpiece of the telephone. The further end of this link is held by the teeth of the deaf person, and the vibrations can thus be transmitted to the auditory nerves. The under surface of the link is provided with an elastic coating which prevents the vibrations from affecting the teeth of the lower jaw.

THE phenomenon lately discovered by Hall of the action of a magnet in altering the path of a current of electricity in the conductor which carries it, has formed the starting-point for two investigations, which have appeared separately in the *Wiener Anzeiger*, by Boltzmann and Von Ettingshausen respectively, in which they point out that this discovery may be applied to determine the absolute velocity of electricity in a conductor.

ELECTRIC LIGHTING. — The works at the new reservoir, Bradford, are being lighted by two of Mr. Crompton's lamps, so that the labour goes on continuously.

THE Edison electric lamp, it is stated, has been tried with success on the Oregon Railway and Navigation Company's steamship *Columbia* during a recent voyage.

IT is proposed to utilise the Canadian Pacific Railway as part of the route for a new telegraph line from Europe to Asia, to be entirely under English control. The terminal station will probably be Hong-Kong.

AT the present time there are over 6,000 miles of wire in use for telephonic purposes in the United States.

M. CLÉMANDOT employs slag wool for diffusing the light in electric lamps in the place of ground or opal glass; the material is placed in tubes, and is more or less lightly packed according to the degree of opacity required. These tubes form the sides of the lantern within which the electric light is placed.

ON the 12th instant a brilliant display of Aurora borealis was observed in several parts of the United Kingdom, and during the day strong earth currents were found to exist on several of the telegraph lines, the strength in some cases being so great as to interrupt the working of the lines. In connection with this "magnetic storm," we may mention some curious and interesting facts which have been brought to our notice as regards the distribution of these earth currents. On the day on which the disturbances were observed, it was noticed that strong earth currents traversed the 1871 Marseilles-Algiers Cable, whilst on the 1879 cable, which runs parallel to the former for the entire distance, no disturbances occurred. On the Marseilles-Barcelona Cable, earth currents were also observed; further, it was noticed that similar currents existed on the Lisbon-Vigo cable of the Eastern Telegraph Company, whilst on the cable which runs parallel to it for a considerable distance, and which extends to the Land's-end, no currents were observable. Again, on the overland line between Bilbao and Madrid, strong currents interfered with the working, though no trouble was found on the lines running north of Bilbao. Now the existence of a current on a line indicates a difference of potential between two points. Since no current existed on the 1879 Marseilles-Algiers Cable, the potential at the two terminal stations must evidently be equal. The fact of a current existing on the 1871 cable would seem somewhat difficult to account for if it did not happen that at a distance of 70 miles from Marseilles a fault existed in the cable; at this point then the potential of the earth must have been different from the points north and south of it. The existence of the current in the Eastern Company's Cable is similarly accounted for, since a fault exists in this cable not far from Lisbon. A straight line joining the faults in the two cables in question, curiously enough, passes through Madrid and also through Barcelona. From these facts it would seem that a distinct line of potential existed during the time the disturbances existed, the value of which was different from the potential a short distance north or south of it. It would be interesting to know whether this line or belt of high or low potential extended beyond the limits pointed out, and if so, whether its direction deviated to the right or left. The direction of the line, curiously enough, was almost exactly magnetically east and west.

WE understand that the Postal Telegraph Department has become the purchaser of the business and premises of Mr. Stroh in the Hampstead-road. Much comment is made as to the wisdom of the policy of the Post-Office Department in manufacturing for themselves instead of putting their requirements up for tender by the best manufacturers. It must, however, be borne in mind that the manufactory lately Mr. Stroh's contains all the special appliances he has had made and has constructed for the making of the Wheatstone apparatus, of which the department is likely from time to time to require more.

THE electric light is now progressing most hopefully, its use for advertising purposes, as at rinks, music halls, &c., having died out, and its general commercial application being made even more and more increasingly apparent.

Mr. Rapieff's light at the *Times* office has been still further extended, there being 31 lamps now in use, viz., 3 in the imposing room, 1 in the hall, 8 in the south composing room, 6 in the north ditto, 4 in the reading room, 3 in the composing-machine room, and 6 in the machine room.

The new office of the *Guardian* at Warrington is being fitted up by the British Electric Light Company. The building is peculiarly adapted for the electric light, as it is but one storey, covers a space 150 by 93 feet, and has its inside walls lined with white glazed bricks, which will materially reflect the light. The arrangements comprise two Gramme machines, giving light to four burners, each 4,000 candle-power. These machines will require about 10-horse-power to drive them, which will be found by steam or gas engines, both being provided for the new works.

The "Anglo-American Electric Light Company" are pushing ahead with their new works, and are obtaining considerable orders. They have recently applied the "Brush" light to a shipbuilding yard at Barrow-in-Furness, where 32 lights are used; the number is to be increased to 80. At Liverpool-street Station, the number of Brush lamps now employed is 31, and the installation is now said to be permanent. The same company have also applied their system to lighting with 16 lights Messrs. Bass & Co's. brewery at Burton, the number of lamps also in this case is to be extended. The Government are extending the use of the Brush light to another of the ironclads, and the authorities at Woolwich Arsenal have caused the carpenters' shops therein to be illuminated by the same system.

The progress of the light, however, cannot perhaps be better illustrated than by the fact that Messrs. Siemens Brothers have at the present time over 1,000 of their machines in use for electric lighting.

THE telegraph service of Ceylon, hitherto worked by the Indian Government, has been taken over by the Government of the island.

MR. R. CROWE of Liverpool communicates to the *British Journal of Photography* an account of some attempts to photograph a landscape by the aid of lightning-flashes. A gelatine plate, requiring by day an exposure of two seconds, was exposed from 10.15 p.m. to 10.45 p.m., during which time there were 120 brilliant flashes and about half as many minor ones. Most of these were in a horizontal direction, and five or six of them were imprinted on the negative. A perpendicular flash which struck a church-tower half a mile away was rendered with extraordinary sharpness and brilliancy. The surrounding objects, in spite of the long exposure, were but feebly impressed; whence Mr. Crowe argues that though the light of a flash of lightning is of a very actinic character, there still is not sufficient volume of light to illuminate a landscape or building to allow a successful photograph to be taken. Mr. Crowe further suggests that an attempt should be made to photograph, for scientific purposes of reference,

the varied forms assumed by lightning at different times and in different countries.

IN a communication to the Göttingen Society of Sciences (*Nachr.*, No. 13), Herr Wöhler states that with aluminium *alone* and with very few elements, a galvanic battery may be formed of strength sufficient to deflect a magnetic needle strongly, decompose water, and raise a thin platinum wire to glow. In a cylindrical glass vessel holding very dilute muriatic acid or dilute soda lye, is placed a roll of sheet aluminium, and within this a porous cell containing concentrated nitric acid and a smaller roll of aluminium. A projecting piece of the metal from each roll is inserted in a circular cover of ebonite.—*Nature.*

ON the occasion of the last meeting of the British Association at Swansea, in 1848, a paper was read by Mr. F. Wishaw "On the Telekouphon, or Speaking Telegraph." The apparatus is not an electrical arrangement, as some scientific papers have assumed; it is nothing more than the common speaking-tube, which appears to have been a novelty at the period when the communication was made to the Association.

BY a presidential decree, dated July 22nd, the French Senate and Chamber of Deputies have approved the telegraphic convention concluded on the 14th March, 1880, between France, Spain, and Portugal, and the ratifications of this Act having been exchanged at Paris on the 21st July, 1880, its full and complete execution was agreed upon. The following are the most important articles of this convention:—Article 1: The tax on ordinary telegrams exchanged between France and Portugal is fixed at a uniform charge of 25 centimes per word. Article 2: This tax will be reduced to 20 centimes per word as soon as the French and Portuguese administrations are agreed that an increase of 20 per cent. in the traffic receipts between France and Portugal has taken place since the year 1878. Article 8: The preceding arrangements will be applicable to correspondence exchanged between Portugal on the one hand, and Algiers or Tunis on the other, by cables which land on French soil. But an additional tax of 10 centimes per word will be levied on submarine telegrams which are exclusively French.

SOME experiments with the telephone have just been made on the cable belonging to the Cie. Française des Télégraphes de Paris à New York on the section between Brest and Penzance. Experiments were first made with the principal systems known, such as Bell, Phelps, Gower, Edison, &c., without a satisfactory result. A new system invented by a Dr. Herz was then tried. The voice was well carried across the Channel, and to a further distance of 300 kilometres inland. The important problem of the electric telephone on submarine cables seems to have been decided. At the same time another apparatus by the same inventor was tried. It is destined to play an important part in the telephone systems of large towns. Its object is to neutralise the induction which interferes so much with the telephone. The experiments have fully carried out the expectations of the inventor. These interesting trials were made at Brest in presence of the director of the French Cable, of the superintendent of the telegraph lines, of several Government officials, of engineers, and of scientific men.—*Journal des Débats.*

IT has been noticed that during eruptions of Etna and Vesuvius, tests taken on the Marseilles-Barcelona, and Marseilles-Algiers cables are always very unsteady, positive earth currents being found to flow through the cables.

THE CITY AND GUILDS OF LONDON INSTITUTE.—Every effort is being made by the promoters of this Institute to make the subjects taught as comprehensive as possible, and to make the instruction as thorough as possible. In the electrical branch Professor Ayrton is particularly active, and during the coming winter term the subjects of the electric light and electrical instrument making will be exhaustively treated. The syllabus of the electric light course is as follows:—

Heat produced by an electric current. Meaning of an electric current and of the direction of flow. Current is proportional to chemical decomposition. Meaning of resistance, resistance is proportional to square of the heat produced. Analogy and want of analogy of an electric current with a stream of water. Incandescence. Loss of heat by conduction, radiation, and convection. Vacuum lamps. Ohm's law. Electromotive force. Current and electromotive force necessary to maintain a given conductor at a given temperature. The electric arc. Opposing electromotive force set up in arc. Electric lamps, principles of the most important, Foucault's, Serrin's, Duboscq's, Siemens', &c. Electric candles, Werdermann's, Jablochkoff's. Combination of lighting by arc and by incandescence, Werdermann's, &c. Carbons, manufacture of, resistance of different kinds. Generators of electric currents, batteries, magneto and dynamo-machines, description and classification of the most important, Wilde's, Siemens', Gramme's, Lontin's, &c. Constant current, reverse current producers. Modes of measuring efficiency of current generators, actual results practically obtained. Measurement of light. Photometers. Proper employment of the electric light. Possibility of sub-division.

The Electrical Instrument Making course is very comprehensive, as will be seen from the following syllabus:—

*Electro-Magnets.*—Kind of iron to be used for the core, action of soft iron, hard iron, steel, iron filings, a bundle of iron wires, &c., coefficient of magnetic induction, coercitive force. Length and diameter of core proper to be used in different cases to give the strongest magnet. Covering wire with silk, cotton, &c. Winding on the wire, test for insulation of the layers. Effect of increasing the number of turns in a layer, or increasing the number of layers of wire. Connection between the strength of the electro-magnet and the current, saturation. Best shape to give to the coils, gauge of wire proper to be used in different cases. Should different gauges be used in the different layers of the coil of an electro-magnet? Value of high conductivity copper. Effect of using coils of insulated *iron* wire for an electro-magnet, &c.

*Galvanometers.*—Detectors are galvanoscopes only, Tangent-galvanometer, value of such a galvanometer. shape of coil, length and shape of magnetic needle. Hardening and tempering of steel for magnets. Connection between the current, deflection, number of turns of wire, and diameter of the coil. Error arising from the magnet not being short. Deflection for which this error is a minimum. Gaugain's device, conical coils, serious objection to Gaugain's plan arising from possible error due to eccentricity of needle. Helmholtz's double coil tangent-galvanometer. No necessity for the conical coils employed by instrument makers, shape proper to give to the channel of rectangular coils to diminish error arising from channel not being very small. Three coil tangent-galvanometer is one of the best practical forms. Sine galvanometer, no necessity for the coil being circular or the magnet short. More delicate than tangent-galvanometer, but can only be used for comparing constant currents. In any galvanometer the current proportional to the deflection of the latter is very small. Delicate reflecting galvano-

meters, best shape to give to coils, gauge of wire to be used in the different layers, how affected by the thickness of the silk, proper resistance to give to galvanometers. Tests to be employed during the winding of the wire, method of recording the length used. Astatic combinations, how practically made, measure of the astatic power. Neutralising the earth's force in other ways. Practical use of such methods. Suspending the magnets, torsion in the silk, cleaning and straining the silk fibre. Effect of putting iron in the galvanometer coils. Proper method of insulating the bobbins, and of insulating the terminals, defects of galvanometers as usually made. Dead beat galvanometers for measuring rapidly changing currents, strength of magnetic field, lightness of needle. Speaking galvanometers. Dead beat astatic combinations, construction of. Galvanometers for measuring rapidly reversing currents, such as are produced by dynamo-machines. Induction on the needle of currents in leading wires, how to avoid, &c.

*Shunts.*—Theory of, material to be used for wire in the construction of. Constant total current shunts. Shape to give the outside of a shunt box, &c.

*Resistance Coils.*—Resistance of a wire depends on its length, diameter, material, purity, hardness, temperature, age, &c. Choice of material and size of wire. Winding coils, insulation of, proper method to insulate ends. Testing coils, temperature corrections. Variation of temperature correction in different parts of the same coil of wire. Permanency of resisting power, annealing by time, artificial annealing of finished coils. Baking coils. Exterior of coil box, objection to highly polished ebonite, insulation of. Suitable coils to form a set. Plugs, revolving arms, slides. Thomson's and Varley's sliding coils, principle of, construction of circular forms. Standard coils, construction and testing of. Defect in standard coils as commonly made. Hermetically sealed coils. Method of constructing cheap accurate resistance coils, &c.

*Condensers.*—Construction of, materials employed. Necessity of drying the insulating compounds. Injury done by overheating a dielectric. Modes of purifying paraffin, shell-lac, &c. Capacity of a condenser depends on the area of the conducting coatings, the thickness, nature, and temperature of the dielectric. Practical methods of measuring the capacity and insulation of condensers. Adjustment of capacity. Effect of residual charge, how to diminish. Manufacture of condensers to be used with very high electromotive forces. Absolute condensers with calculable capacity, construction and practical use of.

Artificial cables, use and construction of. Tests of capacity, insulation of the dielectric, and resistance of the conductor. How to adjust each. Outside of condenser boxes, proper mode of making the terminals, &c.

THE length of underground wires on the Brooks' system which has recently been in course of laying near the Nine Elms Station of the South Western Railway has been completed, and the tests of the same are very satisfactory.

PERMISSION has been conceded by the Government of Colombia to the Central and South American Cable Company to lay a cable on the west coast of Panama, connecting it with the Central American coast, and thence with other lines to Mexico and the United States. This permission does not imply an exclusive privilege.

A VAST telegraph scheme, says the *Montreal Witness*, which in this age it would be folly to decry as impracticable, is mooted, Mr. F. N. Gisborne, superintendent of the Dominion Telegraph Signal Service, being mentioned as the author. It is no less than to connect America with Asia and Europe, under British auspices, by a system of which a line from the Atlantic to the Pacific through Canada is to form a part. To effect this portion of the scheme, a line from Edmonton, Northwest Territory, to Cache Creek, British Columbia, remains to be built. A cable from Vancouver Island to the Aleutian Islands will constitute the major portion of the connection with Asia, a few minor links remaining to complete an electric girdle around the earth, with Britain's hands on the buckle. A cable from Japan to Australia, by way of the Kurile Islands, is a supplemental part of Mr. Gisborne's scheme, of great moment to imperial interests. The consummation of the entire project would give the Imperial Government facilities for instantaneous communication with the principal possessions of the Empire, which would be a boon of incalculable value to the power that stands unique in the extent and remoteness from herself and from each other of her colonies.

IN no department of the W. U. Telegraph Company has the volume of business so suddenly and enormously increased as in the cable department. Cablegrams, at one time counted by hundreds, are now registered up in the thousands. This unprecedented increase of business is, of course, due to the late large reductions in cable rates. Not only have messages poured in vast numbers, but they have been much lengthened. Many customers write long letters daily to their European houses and transmit them over the cables. It is wonderful to observe the number of office messages received and answered daily at the Cable Department, at 197, Broadway, concerning cablegrams to and from all parts of the globe. In this, as well as all other business relations, New York City is the grand clearing house for the whole Western continent.—*Magnet.*

THE Bell Telephone Company of Canada has just closed with the Montreal Telegraph Company for the purchase of the latter company's telephone business and plant. The price, 75,000 dols., is to be paid 50,000 dols. in cash and 25,000 dols. in stock. This gives the Bell Company complete control of all the telephone business of Canada except Toronto, and it is expected that the negotiations for the purchase of the Toronto Company will be completed in a few days. The price is said to be 22,500 dols. in cash and stock. It is understood that Mr. H. Neilson is to remain as manager of the Toronto Company, as at present.—*Operator.*

IN a paper on the earth as a conductor of electricity, Prof. Trowbridge, of Harvard, arrives at these conclusions: 1. Disturbances in telephonic circuits usually attributed to effects of induction are in general due to contiguous grounds of battery circuits. A return wire is the only way to obviate these disturbances. 2. The well-defined equipotential surfaces in the neighbourhood of battery grounds shows the theoretical possibility of telegraphing across large bodies of water without employment of a cable; and leads us to extend greatly the practical limit set by Steinheil. 3. Earth circuits have an intermittent character, with periods of maxima and minima, which may occur several times a minute during the entire day. This intermittent character is seldom absent.—*Magnet.*

AN exhibition of electric light and other apparatus is announced for September 27th at the Alexandra Palace. Manufacturers, contractors, and others who are interested we refer to advertisement on page 10.

ELECTRIC light companies and others, who intend estimating for lighting several of the City thoroughfares, are required to send in their tenders by two o'clock on the 10th September, as will be seen by advertisement, page 10.

# New Patents—1880.

3219. "An improved method and apparatus for obviating the effects of extraneous electrical disturbances on telephonic lines." J. IMRAY. (Communicated by Dr. C. Herz.) Dated August 6.

3310. "Improvements in insulating telegraph conductors, and in the mode of, and in machinery for, manufacturing telegraph conductors, the improved machinery being also applicable for other purposes." E. T. TRUMAN. Dated August 14.

3231. "Telephonic apparatus." H. H. LAKE. (Communicated by L. Maiches.) Dated August 7.

3324. "Dynamo-electric, magneto-electric, and electro-dynamic machines." C. G. GUMPEL. Dated August 16.

3373. "Heliostats, or instruments for signalling by sun flashes." T. ANDERSON. Dated August 19.

3420. "Electro acoustic apparatus, called 'Phonophore.'" F. R. VON WREDEN. Dated August 23.

3424. "Improvements in electric conductors, and in a compound or compounds for preventing the deterioration of rubber insulators." G. BARKER. (Communicated by W. W. Jacques.) Dated August 24.

3438. "Mode and means of and fastener for securing telegraph wires to their insulators." A. E. GILBERT. Dated August 25.

## ABSTRACTS OF PUBLISHED SPECIFICATIONS, 1879.

5045. "Inclinatoriums or dipping azimuth compasses." J. IMRAY. (A communication from Joseph Peichl, of Trieste.) Relates to a construction of compass which serves independently of any extraneous sighting beyond the ship, firstly, to ascertain the coefficient of deviation or the total deviation of a compass; secondly, to ascertain small amounts of the total deviations in the course steered in ships' azimuths, deviating at most 30° from such course; and, thirdly, to enable the compensation of the compass in analogous ships' azimuths to be rectified. A double needle mounted as a dipping needle with pinion has its steel or other axis carried in agate or other bearings in a casing consisting of an upper and a lower part. The lower part has fixed or formed round its outer surface, at about the level of the axis of the dipping needle, a horizontal circular disc suspended by diametrically opposite axes in bearings provided with anti-friction rollers on the gimbal ring. The upper part of the casing is removable, forming a cover. The axes of the gimbal rings are carried in a guide ring which can turn concentrically with the vertical axis of the needle, and which for this purpose rests in a circular seat in a fixed plate, and is provided with adjusting screws and an azimuth index. The claims are, first, for an improved construction of control compass; secondly, the use of an inclination needle with prismatic or double knife edge axis within a casing provided with gimbal ring suspension; thirdly, the use of the inclination needle provided with one or with two mirrors, within the needle casing provided with gimbal ring suspension, as also the use of a scale within the gimbal suspension; and fourthly, the use of induction bars or of one or more of them, whereby the changes of inclination of the needle due to alterations of the course are accelerated, thus increasing the sensitiveness of the apparatus.

5078. "Electrical signal apparatus." W. R. LAKE. (A communication from F. Blake, Junr., of Weston, U.S.A.) Dated December 11. 6d. Relates to electric signalling apparatus, and comprises the employment of a pendulum hung as the armature of an electro-magnet in connection with a device for automatically making and breaking the circuit to which the electro-magnet belongs at intervals corresponding to the rate of vibration of the pendulum. It also comprises the employment of a series of pendulums of different lengths, in connection with a series of electro-magnets in a common circuit, and a suitable device for automatically making and breaking the circuit at intervals corresponding to the rate of vibration of either pendulum. Also it comprises the employment of two pendulums vibrating in equal times, one hung as the armature of an electro-magnet, and the other operating a circuit closer to make and break the circuit containing the electro-magnet at each vibration.

5085. "Dynamo-electric machines and electro-motive engines." W. L. WISE. (Communicated by Emil Bürgin of Basel.) Dated December 11. 8d. This invention is designed to produce compact and simple machines for the production of continuous or of alternative currents of electricity, and consists in a novel construction of the generating cylinder, in a novel combination of a commutator with such cylinder, and in certain details of construction.

5114. "Facilitating telephonic communication." W. R. LAKE. (Communicated by M. D. Connolly and others.) Dated December 13. 8d. Has for its object to provide an "*automatic* telephone exchange." By the employment of electricity and electro-magnetism all the operations of the central office are rendered automatic. Any member may communicate with any other member whose line is unoccupied; at the same time he can isolate his own and the line he desires to communicate with from all others. He is enabled to signal the member to be communicated with and receive the answering signal, and while these two are using their lines all the other members can be using their lines two and two without any interference of one line with another. Each station comprises the usual battery, a telephone, a call bell, a reversing key, a compound switch, and a dial instrument. The latter produces breaks in the electric current, the number of said breaks being indicated on the dial by a pointer, and causes the central office mechanism pertaining to the given line to operate and establish the connection of the two lines. Then the current is reversed and brings into action mechanism at the central station which isolates the connected lines and rings the bell at the station to be called. At the station this signalling main is then switched to the bell. The person at the signalled station now shunts his battery into the main line and rings the bell at the signalling station. Both persons now switch to their respective telephones, cutting out the bells, and if necessary, the batteries from main line, when conversation may be carried on. When they cease talking the two parties restore the devices to their normal condition so that other persons may communicate with either.

5119. "Electric telegraphs." Sir JAMES ANDERSON, Knt., and FRANCIS STRUDWICK HARWOOD. Dated December 13. 2d. Has for its object to increase the speed of signalling through submarine telegraph cables and covered land lines when working "duplex," although part of the invention may also be used to facilitate "simplex" working. The object is attained when

working "duplex" by applying that pole of the battery required for the signal, to be made through a suitable key direct to the cable itself without the intervention of any resistance coils. Secondly, by providing for perfectly neutralising or "wiping out" the effects of induction in the cable by applying to it after each signal an induced current of the opposite sign, graduated, to be of exactly the same potential and duration as the induced or "return" current that is set up in the cable by the application of the currents of the signalling battery. Thirdly, by avoiding the use between the signalling battery and the cable in sending, or between the cable and the receiving instrument in receiving, of any resistance coils in a position to cause retardation to the signals by passing the signalling currents through them. *(Provisional only.)*

5126. "Electric signalling apparatus for use in the loading and unloading of ships." W. WHITE. Dated December 15. 2d. Comprises an electric alarm bell of ordinary construction and recording arrangement, which is fitted in a wooden box in the engine room, or other convenient situation near the engine man or other attendant, and is connected by separate insulated wires with an improved construction of communicator or contact-making apparatus to be held in the hand of the person in charge of the loading operations. *(Provisional only.)*

5127. "Electric lamps." T. A. EDISON. Dated December 15. 6d. Relates to an improvement in the process of manufacturing the carbon filament used in the patenteed glass bulb lamp, from which the atmosphere has been as nearly as possible removed. Narrow strips of "Bristol board" preferably in the form of an elliptical bow or an arc of a circle, the ends of the strip being by preference wider than the other portions. Several of these are laid in a mould and a light weight placed over them, and the mould is then raised very gradually to a temperature of about 600° Fahr. The mould is then placed in a furnace and heated almost to a white heat, and afterwards removed and allowed to cool gradually.

5149. "Telephones." JOHN IMRAY. (A communication by J. F. Bailey, U.S.A.) Dated December 16. 6d. Relates to telephones of the kind in which a current from a battery in passing through the transmitter undergoes variations resulting from action on an imperfect conductor, such as carbon, by a membrane or diaphragm caused to vibrate by sound impulses.

5156. "Electric light regulators." S. PITT. (A communication from C. E. Scribner, of Chicago.) Dated December 16. 8d. Describes an arc lamp. One of the carbon holders, say the upper, is attached to a rod or metallic stem which is held loosely in a spring or friction clip, this clip being carried upon the armature of an electro-magnet which is capable of working up and down a distance about equal to that by which the carbons are separated when the light is properly displayed. This electro-magnet is in the main circuit, and so soon as a current passes, the armature is attracted, and it raises with it the rod, the carbon holder, and carbon, for there is a special device to insure that the armature shall in its upward movement carry the rod with it. Immediately that the arc ceases the armature falls away from the magnet and the carbon points are brought into contact, re-establishing the circuit. The automatic feed to compensate for the consumption of the carbon while the lamp is burning is effected by means of another electro-magnet and armature. The coils of this magnet are in a short circuit or shunt by which the electric arc is shunted, hence, as the resistance of the arc increases from the burning away of the carbon, the amount of current passing in the shunt circuit becomes gradually greater and the armature more strongly attracted. This armature is suspended by springs, and its movement towards the poles of the magnet takes place in a downward direction.

5157. "Magneto-electric machines and electric light apparatus." H. F. JOEL. Dated December 16. 10d. Consists essentially of a new, simple, and convenient combination of inducing electro-magnets or permanent magnets with induced electro-magnetic armatures or coils, whereby great surface is brought into magnetic action, and a special and additional induction current is produced by the reaction of the aforesaid armature coils upon the wire of the inducing electro-magnets or upon separate coils, the armature coils thus becoming in their turn inducing magnets. Also of special arrangements whereby constant currents are produced without a commutator and also of a peculiar construction and arrangement of inducing electro-magnets. Likewise of an arrangement whereby the retention of magnetism in the induced core is made to automatically regulate, by means of a commutator, the change of direction of the currents. An arc lamp is also described.

5167. "Safety alarm signalling apparatus for steam boilers." W. WHITE. Dated December 17. 6d. In addition to the usual indicating hand of a steam pressure gauge, there is fitted a stationary pointer which may be moved round by hand and set to any desired degree of pressure. When the steam pressure causes the moving hand to travel round to the stationary pointer, electric contact is made and a bell is rung. A similar arrangement may also be used as a water level indicator.

5175. "Insulating mariners' compasses." A. W. LOVELL REDDIE. (A communication from J. B. Siccardi, of Varazze.) Dated December 17. 2d. To effect insulation a box is provided, say about 28 inches square by 20 inches high, made of wood or other non-conducting material; this box is constructed at the top with a well in the centre of sufficient depth to contain the compass which is to be insulated, the top of which, when fitted in the well, will be about flush with the top of the box. The interior of the box is then filled with sea sand of moderate coarseness which closely surrounds the shallow well containing the compass on all its sides and bottom. *(Provisional only.)*

5177. "Lighting gas by electricity." JAMES MACKENZIE. Dated December 17. 6d. Consists of an arrangement for starting and stopping clockwork, which actuates a switch by means of the same battery current which produces a secondary current, and so lights the gas, thus admitting of the induction coil and the switch being fixed close to the chandelier or other series or groups of gas-burners to be lighted.

5219. "Galvanic batteries." THEOPHILUS COAD. Dated December 20. 6d. The usual positive and negative electrodes are employed and any suitable fluids, but a cock is applied to each of the outer cells for drawing off the fluid when required; or the cells may be connected by suitable pipes and stop-cocks so that they may all be filled or emptied from one cell.

5319. "Telephonic exchange system." ERNEST DE PASS. Dated December 30. 2d. Proposes to overcome objections to the present system by using two wires and circuits, one for connection or disconnection calls or signals, and the other for private communication between subscribers. A system without employing two wires and circuits is also described. *(Provisional only.)*

THE following letter has been published by the managing director of the Anglo-American Telegraph Company:

Sir,—I beg to inform you that an additional line of telegraphic communication across the Atlantic has just been completed by the laying down of a new cable between this Company's stations at Heart's Content, Newfoundland, and Valentia, Ireland. The work has been most successfully carried out by the Telegraph Construction and Maintenance Company without a hitch having occurred during the whole operation. The ships employed have been the *Scotia*, ss., and the *Seine*, ss., the expedition having been under the command of Captain Halpin; the electrical arrangements under the charge of Mr. J. C. Laws, on behalf of the Construction Company, and of Mr. C. Hockin, of the firm of Clark, Ford, and Co., on behalf of the Anglo-American Company. This is the seventh cable laid by the Telegraph Construction and Maintenance Company across the Atlantic for the Anglo-American Company and their predecessor, four of which are now in working order. The expedition started from Heart's Content on the 10th inst., and the final splice was completed off the coast of Ireland on the 21st inst., a period of 12 days, being the quickest Atlantic cable passage on record.—I am, Sir, your obedient servant,

H. WEAVER, Managing Director.

Anglo-American Telegraph Company (Limited),
26, Old Broad-street, London, E.C., August 23.

WE are informed that Mr. Edward Cross has resigned his seat on the board of the Western and Brazilian Telegraph Company. It is also announced that Mr. Sam. Mendel has resigned his seat at the board.

ACCORDING to the *Paris Bourse* a joint purse arrangement has been made between the Anglo-American and Direct Cable Companies with the Pouyer-Quertier Cable, under which the latter obtains 16 per cent. on the common receipts. These terms have not been easily obtained, and may be considered favourable. This announcement occasioned a considerable rise in the price of Atlantic Cable shares, which, however, drooped away to some extent on a statement being made that the negotiation had at the last moment failed. Since then another paragraph on the subject has appeared in the *Paris Bourse*, it runs as follows:—"The meeting of the delegates with M. Pouyer-Quertier for the purpose of exchanging the signatures of the contract, which on every point has been agreed to by all the parties concerned, has taken place. A technical question, however, turned up at the last moment, and the parties decided to postpone the signature until it was solved. This is the cause of the delay, and we may add that it is almost tantamount to a mere formality."

The following are the final quotations of telegraphs for the 31st August.—Anglo-American Limited, 66-66¼; Ditto, Preferred, 97-97½; Ditto, Deferred, 36¾-37¼; Black Sea, Limited, ——; Brazilian Submarine, Limited, 9-9¼; Cuba, Limited, 9½-9¾; Cuba, Limited, 10 per cent. Preference, 16½-17; Direct Spanish, Limited, 1¾-2¼; Direct Spanish, 10 per cent. Preference, 11½-12; Direct United States Cable, Limited, 1877, 12¾-12¾; Scrip of Debentures, 103-105; Eastern, Limited, 9¾-10; Eastern 6 per cent. Preference, 12¾-13; Eastern, 6 per cent. Debentures, repayable October, 1883, 106-108; Eastern 5 per cent. Debentures, repayable August, 1887, 103-106; Eastern, 5 per cent., repayable Aug., 1899, 103-106; Eastern Extension, Australasian and China, Limited, 9¾-10½; Eastern Extension, 6 per cent. Debenture, repayable February, 1891, 106-109; 5 per cent. Australian Gov. Subsidy Deb. Scrip, 1900, 103-105; Ditto, registered, repayable 1900, 103-106; Eastern and South African, Limited, 5 per cent., Mortgage Debentures redeemable 1900, 102-104; Ditto, ditto, to bearer, 101-103; German Union Telegraph and Trust, 9-9½; Globe Telegraph and Trust, Limited, 6¾-7; Globe, 6 per cent. Preference, 12½-12¾; Great Northern, 9½-9¾; Indo-European, Limited, 24¾-25½; London Platino-Brazilian, Limited, 4¾-5¼; Mediterranean Extension, Limited, 2¾-3¼; Mediterranean Extension, 8 per cent. Preference, 10¾-11¼; Reuter's Limited, 9¾-10¼; Submarine, 240-250; Submarine Scrip, 2¼-2½; West Coast of America, Limited, 2¼-2½; West India and Panama, Limited, 1¼-1¾; Ditto, 6 per cent. First Preference, 7¾-8; Ditto, ditto, Second Preference, 7-7½; Western and Brazilian, Limited, 7-7¼; Ditto, 6 per cent. Debentures "A," ——; Ditto, ditto, ditto, "B," 96-99; Western Union of U. S. 7 per cent., 1 Mortgage (Building) Bonds, 120-125; Ditto, 6 per cent. Sterling Bonds, 104-107; Telegraph Construction and Maintenance, Limited, 34½-35; Ditto, 6 per cent. Bonds, 106-109; Ditto, Second Bonus Trust Certificates, 3⅛-3⅜; India Rubber Company 15¾-16¼; Ditto 6 per cent. Debenture, 105-107.

## TRAFFIC RECEIPTS.

| Name of Co. with amount of issued capital, exclusive of preference and debenture stocks. | Anglo-American Co. £7,000,000. | Brazilian Sub. Co. £1,300,000. | Cuba Sub. Co. £160,000. | Direct Spanish Co. £116,379. | Direct U.S. Co. £1,213,900. | Eastern Co. £3,697,000. | Eastern Ex. Co. £1,997,500. | Gt. Northern Co. £1,500,000. | Indo-Euro. Co. £425,000. | Submarine Co. £338,225. | West Coast America Co. £300,000. | Western and Brazilian Co. £1,398,200 | West India Co. £883,210. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | £ | £ a | £ | £ | £ | £ | £ | £ | £ | £ | £ | £ a | £ |
| July, 1880 ... | * | 12,045 | 2,800 | 1,423 | * | 45,279 | 32,194 | 23,560 | ... ... | ... ... | ... ... | 9,929 | 3,701 |
| July, 1879 ... | 49,320 | 16,299 | 2,932 | 913 | 16,440 | 35,789 | 23,411 | 20,421 | ... ... | 11,733 | ... ... | 10,697 | 4,877 |
| Increase ... ... | ... ... | ... ... | ... ... | 510 | ... ... | 9,490 | 8,783 | 30,39 | ... ... | ... ... | ... ... | ... ... | ... ... |
| Decrease ... ... | ... .. | 4,254 | ... ... | ... ... | ... ... | ... ... | ... ... | ... ... | ... ... | ... ... | ... ... | 168 | 1,176 |

* Publication of receipts temporarily suspended. *a* Five weeks.